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ABSTRACT

To determine the effectiveness of mathematical vocabulary training on the problem solving ability of third and fourth grade students, 66 students were placed into either an experimental or a control group. All were pretested and posttested with an experimental mathematics vocabulary test and with a standardized mathematics test. Mathematical vocabulary was then taught to the experimental group for eight weeks. The results favored the experimental group. There were significant differences between the gain scores of the two groups on both the vocabulary test and on the standardized test. The findings suggest that systematic mathematical vocabulary training increased the problem solving ability of third and fourth grade students. (Author/FL)

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EFFECTS OF MATHEMATICAL VOCABULARY TRAINING ON PROBLEM SOLVING ABILITY OF THIRD- AND FOURTH-GRADERS

A MASTER'S EQUIVALENCY THESIS

SUBMITTED TO THE FACULTY

OF THE GRADUATE SCHOOL OF EDUCATION

OF

RUTGERS UNIVERSITY
The State University of New Jersey
BY

ALDONA SKRYPA

IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS FOR THE DEGREE

OF

DOCTOR OF EDUCATION

NEW BRUNSWICK, NEW JERSEY APRIL, 1979

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ABSTRACT

The purpose of this study was to determine the effectiveness of mathematical vocabulary training on problem solving ability of third- and fourth-graders.

Problem

The problems that were basic to this study were the following:

1. To determine whether systematic mathematical vocabulary training would increase mathematical reading ability.

2. To determine whether mathematical vocabulary training would improve problem solving ability.

Procedures

The subjects were 66 students who comprised the entire third and fourth grade population of an elementary school in Central New Jersey. The subjects were divided into an experimental group and a control group, each consisting of 33 subjects.

All subjects were pre- and post-tested with an experimenter-constructed Mathematics Vocabulary Test, Forms A and B. Additionally, all subjects received the Stanford Diagnostic Mathematics Test, Green Level, Forms A and B.

The experimenter taught mathematics vocabulary to both the third and the fourth grade groups. Contact time was 45 minutes a day, four days a week, for a period of eight weeks. The mathematics vocabulary taught in the experiment was compiled from the third and fourth grade Addison-Wesley Text Investigating School Mathematics and from the I.R.A. (International Reading Association) list of the most frequently occurring words in current mathematics texts.

Statistical analyses were made when the pre- and post-test means of the experimental and the control group were compared. "t" tests were done on all the test results to determine if significant differences had resulted from the treatment effects.

Findings

The results favored the experimental group. There were significant differences between the gain scores of the experimental and the control groups on the Mathematics Vocabulary Test. Results were significant at the .001 level.

Significant differences were also obtained between the gain scores of the experimental and the control groups on the Stanford Diagnostic Mathematics Test. On Test I: Number System and Numeration, the difference was significant at the .02 level and on Test III: Applications, the difference was significant at a greater than .001 level.

Conclusion

The findings of this study indicate that systematic mathematical vocabulary training increased problem solving ability of third- and fourth-graders.

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CHAPTER I

INTRODUCTION

Many excellent and many weak readers have problems in mathematics because they are not able to read and understand printed mathematics materials. Numerous reports in the literature link difficulty in learning mathematics to reading problems. (Herber, 1978; Balow, 1964; Lyda and Duncan, 1967).

At recent national meetings of the International Reading Association and the National Council of Teachers of Mathematics, speakers have expressed the need to teach reading skills that will enable students to deal with mathematical materials more effectively. The International Reading Association (Earle, 1976) and the National Council of Teachers of Mathematics (Spencer and Russell, 1960) are in agreement that acceptable achievement in mathematics is closely related to the student's ability to read mathematics materials, to acquire vocabulary and to formulate concepts.

Most writers in the fields of reading and mathematics seem to recognize the need to teach the skills necessary for reading mathematics. However, most of the writing in this area has been

anecdotal and prescriptive, without a research base. Relatively few persons have examined theoretically the relationship between reading and mathematics.

Until recently, most of the emphasis on teaching reading in mathematics, as well as in other content areas, had been at the secondary level. Vanderlinde (1964) was one of the first investigators to conduct a study with elementary school subjects. The purpose of his investigation was to assess the effects of quantitative vocabulary teaching to fifth-graders. There appears to be a need for similar research studies at the lower elementary levels.

The Problem

The purpose of this study was to determine whether systematic teaching of mathematical vocabulary would result in improved mathematical reading and in greater proficiency in mathematical problem solving.

Hafner, Weaver, and Powell (1970) at the elementary level and Davis (1968) at the secondary level have shown that word knowledge is the most important factor in reading comprehension. If this is the case, mastery of mathematical vocabulary should provide a basis for the acquisition of mathematical concepts and increased facility with problem solving.

The Hypotheses

The null hypotheses of this study were as follows:

1. There would be no significant differences between the experimental group and the control group in mathematical reading ability, as measured by the experimenter-constructed vocabulary test.

2. There would be no significant differences between the experimental and the control group in problem solving ability, as measured by the Stanford Diagnostic Mathematics Test.

Importance of the Study

There are few elementary level research studies which concern themselves with the teaching of mathematical reading skills. There do not appear to be any previous mathematical vocabulary training experiments with third- and fourth-graders. Therefore, this pioneer study will add to the scant research presently available.

Definition of Terms

In terms of this study, mathematical vocabulary will consist of:

1. The technical and specific words and symbols which are restricted to the mathematics discipline, such as ratio, addend, and commutative.

2. Polysemantic or interchangeable words which have meanings that are used in other disciplines, but have precise mathematical meanings, such as set, check, and factor.

Training refers to a planned, systematic procedure of teaching a selected group of mathematical words and symbols.

Problem Solving Ability will be evidenced by the students' accurate perceptions of the essential symbols, understanding the reading component of problems, and correct solutions to problems on the Stanford Diagnostic Mathematics Test.

Limitations of the Study

Although reading skills in general are important to overall success in mathematics, this study limits itself to the teaching of mathematical vocabulary.

The population used for the study consisted of 66 third- and fourth-graders. This was a fairly heterogeneous sample, since some pupils came from working-class homes; others were children of Drew University graduate students. However, the total sample was relatively small. Therefore, the results of the study may not be generalizable to other samples.

Although whole classes were used for the study, randomness is implied, because students of all abilities were distributed evenly in these classes.

Even though temporal factors and experimental procedures were closely followed, the experimenter taught both experimental groups. This may represent a limitation.

Overview of the Study

Participants in the study were 34 third-graders and 32 fourth-graders. On the basis of IQ and standardized test results, the range of abilities in the third and fourth grade groups appeared to be the same. (See Table 1 on page 34). Therefore, the materials used in the experiment were appropriate for both grade levels. Thirty-three subjects were assigned to the experimental group, and the remaining thirty-three subjects comprised the control group.

The experimenter taught mathematics vocabulary to the third and fourth grade groups separately, controlling procedures, materials, and temporal factors. Contact time was 45 minutes a day, four days a week, for a period of eight weeks.

While the experimenter was working with the fourth grade group, one of the fourth grade teachers taught social studies to the experimental third grade group. For this, the third- and fourth-graders switched classes. The control group also had social studies during this block of time.

General mathematics instruction was given separately by each homeroom teacher. All four teachers used the individual progress plan. The Addison-Wesley text Investigating School Mathematics (Eicholz, O'Daffer, and Fleenor, 1973) was the main instructional source.

The mathematical vocabulary taught in the experiment was compiled from the third- and fourth-grade texts Investigating School Mathematics (Eicholz, O'Daffer, and Fleenor, 1973) and from the I.R.A. (International Reading Association) list of the most frequently occurring words in current mathematics texts. (Earle, 1976).

This mathematical vocabulary was introduced through:

1. Filmstrips
2. Motion Pictures
3. Concrete Materials, such as Models of Geometric Shapes
4. Pictures

Group discussions played an important part in these lessons. Each student kept a notebook with definitions of the words introduced at each session. For additional drill and reinforcement, this same vocabulary was used in experimenter-designed bingo-type table games. Every student in the experimental group was assigned to the drill exercises for equal periods of time.

At the beginning and conclusion of the study, the following tests were administered to the experimental and the control groups:

1. Stanford Diagnostic Mathematics Test, Green Level, Forms A and B.
2. An experimenter-designed mathematical vocabulary test. This was a 50-item multiple choice test based on the most frequently occurring words in Investigating School Mathematics and on the I.R.A. list.

CHAPTER II

REVIEW OF THE LITERATURE

The first part of this chapter will deal with a general rationale for teaching reading in the content areas. The second part of the chapter will concern itself with research studies of the relationship between reading ability and mathematical achievement.

A Rationale for Teaching Reading in the Content Areas

Considerable attention has been given to teaching reading in the content areas at the secondary level. It is now becoming a recognized fact that children at the elementary level can benefit from instruction in the specialized reading skills pertaining to the various subject fields. (Hafner, 1977; Karlin, 1975)

In the primary grades, the main emphasis of the reading programs is on learning and practicing basic reading skills. The emphasis is still on learning how to read. But children in grades three, four, five, and six spend considerable amounts of time reading social studies, science, and mathematics textbooks, as well as reference materials, for the purpose of gaining information from which they need to build concepts and generalizations. (Artley, 1948; Kolczynski, 1973)

According to Karlin (1975), the children's purposes for reading informational materials are not the same as for narrative materials; therefore, they must read differently. Reading instruction which is usually limited to helping children understand narrative and fictional writing often fails to take into account difficulties children may encounter when they read in the content fields.

Harris and Smith (1972) reported that content reading is receiving considerable attention these days. Professional organizations are discussing the topics, and publishers are producing materials in the content fields. Harris and Smith define the term "content reading" as one that is used to denote expository writing concerned with "information subjects" and the evaluation of that information. They also feel that children need particular practice in reading content material.

Harris and Smith point out that children have been systematically introduced to the short story, and they spend most of their six years in elementary school learning how to read short stories in the basal readers. Teachers and students spend much time building short story vocabulary, analyzing plots, describing characters, interpreting actions, and applying morals to their own living. When it comes to "information subjects," most of the instructional emphasis seems to go toward recall of specific information and gaining concepts, but since this activity is not

called "learning how to read", many teachers feel that no overt transfer of pedagogy is necessary. This attitude has caused a great deal of difficulty. The natural and relevant place for reading instruction to take place is in conjunction with literature, science, social studies, and mathematics.

The literature which deals with reading in the content areas may be divided into two major areas, vocabulary training and development of comprehension skills.

Vocabulary Training In The Content Areas

According to Artley (1948), each subject area has its own body of concepts and vocabulary, its unique relationships, logic, form of presentation, and its unique assumptions and basic principles.

Stauffer (1966) indicated that even if a child had mastered all the different words presented in all the basal series readers (at a given grade level), he would still need to learn at least one-half of the words presented in mathematics class. This means that he would need to be prepared to deal with these words semantically, phonetically, and structurally, in order to grasp and cope with arithmetic problems and discussions.

Strang (1957) advocates that reading instruction in each subject should be part of the total developmental reading program. She lists three aspects of the teaching of reading in every subject:

1. The general attitude or approach to the kinds of reading required in the subject.
2. The technical or special vocabulary of the subject.
3. Certain specific reading skills needed in the subject, as, for example, the reading of maps in social studies and reading directions in the science project.

Comprehension Skills
In The Content Areas

Kolczynski (1973) states that in mathematics, comprehension is not limited to the understanding of a story. It is not even limited to the understanding of one experiment. One concept is built on another, and mathematics can only have meaning on the basis of the understood meaning of the former.

Elden Bond (1940) pointed out the importance of reading comprehension in mathematical achievement. He also concerned himself with reading rates in the various content fields. Additionally, Elden Bond found that good achievement in one area does not necessarily mean good achievement in another. He suggests that

highly significant relationships would be found to exist between reading and achievement, if the reading measure were based upon reading within the content area.

Herber (1970) presents a rationale for teaching reading in the content fields based on the premise that, with the contemporary explosion of knowledge, the teacher's primary role is no longer to be a single source of facts and knowledge. In a fast-changing world, knowledge about how to acquire and handle facts and theories is as important as possession of the knowledge itself. Bruner has said, "The goal of education is disciplined understanding; that is the process as well." If a teacher accepts this position, then he or she will be more than just an information dispenser. Rather, the teacher will emphasize the means of acquiring, interpreting, and using language independently.

Both earlier and more recent research in the reading field seem to support a rationale for teaching reading in the content subjects. Before reaching definite conclusions about a need to teach reading in mathematics, relevant research in that area should be reviewed.

Research on Reading in Mathematics

Research on the role of reading abilities in mathematics may be classified into three somewhat overlapping areas:

1. Mathematics and General Reading Ability
2. Mathematics and Vocabulary
3. Mathematics and Specific Reading Skills

Because the first two topics are most pertinent to this study, the review of the literature will concentrate on them.

Mathematics and
General Reading Ability

According to Russell (1960), studies dating back to the 1920's indicate positive correlations between reading ability and problem solving scores. These correlations have occurred in the .30 and .60 range, depending upon tests of arithmetic or reading that were used. The multiple correlation between reading ability and problem solving would be .45. (Guilford, 1965)

Since Monroe (1918) showed that a given problem could be stated in twenty-eight different ways, research workers have been interested in the relationship between reading ability and mathematical achievement. The resulting research has not always been clear on what relationship exists, often because of the confounding effects of intelligence. Intelligence is a recognized factor in mathematical and in reading achievement. Monroe, using mental age derived from the Revised Stanford Binet Intelligence Test, found

correlations from .56 to .65 with reading ability. Strang (1957), using the language score on the California Test of Mental Maturity, found correlations between .80 and .84 with reading achievement.

Recognizing that any apparent relationship between reading achievement and mathematical achievement might be spurious and really attributable to intelligence, Fay (1950) controlled chronological and mental age in comparing his groups. Working with good and poor readers, he found no differences in mathematics achievement between the groups with intelligence held constant. That reading achievement would not be related to computation skill with the effects of intelligence controlled is reasonable. Little reading skill is involved in finding arithmetical solutions to examples. The pupil needs to read only numbers and operation signs. This minimum reading knowledge required in computation would result in a very low correlation between reading ability and computation (provided that the effects of intelligence were controlled).

In a more recent study, Warncke and Callaway (1973) confirmed the above findings. Their investigation was designed to determine whether there is a relationship between arithmetic computational ability and reading ability for pupils of normal intelligence who have difficulty in reading. Subjects for this investigation were all second, third, and fourth grade referrals to

the University of Georgia Reading Clinic with IQ's of at least 90. The 75 children who participated in the study had been referred to the Clinic because of reading difficulties.

All subjects were administered the WISC, the Fundamentals Section of the California Arithmetic Test and an Informal Reading Inventory. Mean scores were obtained for each grade level on each variable. Pearson Product correlations were computed to determine if a relationship existed between the subjects' ability to read and do fundamental computation. These correlations were not significant. Correlations between grade placement and computational skill were higher than correlations between reading and computational ability. As a result of this particular study, one might conclude that, at the second, third, and fourth grade levels, the following may be a true statement: "Johnny could be proficient in computation, without being a good reader."

It is in the area of problem solving and mathematical reasoning that reading assumes greater importance. Problems are specified by words. In problem solving, the reader must determine the question being asked, the information given, and the mathematical operations required. He must find this information through reading. Obviously, reading ability is involved at this point.

Balow (1964) designed a study to determine if the level of general reading ability is significantly associated with problem solving ability, and if a high level of ability in one of these areas will compensate for a low ability in the other. Prior studies had a tendency to compare only good and poor problem solvers or arithmetic achievers on reading ability, or had compared good and poor readers on arithmetic achievement or problem solving. Either of these kinds of comparisons had eliminated a large middle or "average" group of students. In Balow's study all levels of ability were represented.

A total of 1400 sixth-grade students in a Southern California community participated in Balow's study. The Stanford Achievement Tests, Intermediate, Form KM: Reading and Arithmetic, were administered in February. The grade placement in reading (average of the scores on the Word Meaning subtests) was used as the criterion of reading ability. Grade placement on the Computation subtest was used as the criterion measure of computational skill, and grade placement on the Reasoning subtest served as a measure of problem solving ability. The California Short-Form Test of Mental Maturity, Elementary, 1957 S Form, was administered and the total IQ was used as a measure of intelligence.

The children were then classified according to level of computational ability and level of reading achievement. Four levels of achievement were used, as determined by grade placement

scores: 1.0 to 5.0, 5.1 to 5.9, 6.0 to 6.9, and 7.0 to 11.5. This classification resulted in sixteen cells. The grade placement score on the Reasoning subtest and the IQ were recorded in the proper cells for each child. Twenty-three students were then randomly selected from each cell. Their mathematical reasoning scores were compared using the analysis of covariance and controlling IQ, to determine the importance of reading ability, computation ability, and interaction on problem solving.

The results of Balow's study showed a high correlation between a student's reading ability and problem solving. There also was a high correlation between computational ability and problem solving.

Balow reached the following conclusions:

1. Reading ability does have an effect on problem solving ability. The investigator suggests that the vocabulary and reading difficulty control of standardized tests (which differ from grade level texts) may actually minimize the effect of reading, and that if a more normal reading situation were employed, reading skill may prove to be even more important.

2. When IQ is not controlled, much of the apparent relationship between reading and problem solving ability is the result of the high correlation of each of these factors with IQ. Controlling IQ drastically reduces the degree of relationship.

3. For a given level of computational ability, problem solving skill increases as reading ability increases.

The findings of Balow's study point out the importance of considering children's reading abilities as well as computation abilities when teaching problem solving skills. Both of these factors are important to the child if he is to deal adequately with verbal problems in his school work.

Mathematics and Vocabulary

Studies in the area of relationships between mathematics and vocabulary indicate a consistently positive and strong relationship between them. Brueckner and Grossnickle (1953) have specified intercorrelations between intelligence and various mathematical skills, with a low of .35 between IQ and computation and a high of .76 between IQ and mathematical vocabulary.

Concepts of ordinal and cardinal numbers, of mathematical processes, of the number system, of weights and measures, of numerous uses of mathematics, as in perimeter, profit, installment buying, and group insurance may pop into the elementary school child's mathematical activities. Knowledge of these specific concepts seems consistently related to problem solving activities. (Earle, 1976)

Nila Banton Smith (1952) has stated that the real trouble makers are the polysemantic words which mean something entirely different when used in different subject contexts. For example, consider the word check. In mathematics the word check means a blank form which one fills in and presents at the bank when he wishes to draw some money on his account. In science the student may be told to check his experiment. In history he reads that a certain group of soldiers were able to check the enemy.

While many students learn these changed meanings incidentally, as they occur in different subject contexts, other students do not. The teacher who cultivates a sensitivity to shifts of word meanings from one subject to another, and who takes the trouble to inquire into his or her pupils' understanding of these words in different contexts, will discover that there is much confusion in the pupils' minds. Thus, it is very important to help them to understand these distinctions.

C. T. Johnson (1949) believed that vocabulary is the main factor in problem solving, ranking ahead of reasoning ability. In a study involving 598 seventh-graders, H. C. Johnson (1944) gave practice on selected arithmetic vocabulary for a period of fourteen weeks. The practice included word drills, use of the dictionary, and keeping individual notebooks for difficult words. Mimeographed

material supplemented to text. He found that the experimental group which had been given vocabulary practice made slightly higher gains not only in mathematical vocabulary but in problem solving which involved some of the words taught. Johnson concluded that training in vocabulary should be made an integral part of mathematical activities from the time the child begins formal work.

Vanderlinde (1964) conducted a study to determine whether the study of quantitative vocabulary would improve problem solving ability. In his investigation he involved all fifth-grade pupils attending the public schools of Bay City, Michigan. On the basis of statistical analysis of the data obtained in this investigation, he arrived at the following conclusions:

1. Pupils who studied quantitative vocabulary using direct-study techniques achieved significantly higher scores on a test of mathematical problem solving than pupils who did not devote special attention to the study of quantitative vocabulary.

2. The experimental method was equally effect with boys and girls.

3. The experimental method was more effective with pupils of average or above average intelligence than those with below average intelligence.

4. Effective vocabulary study can be made a part of the regular mathematics program without sacrificing pupil achievement in the subject itself.

Vanderlinde suggests the following curriculum implications based on the results of his study:

1. Vocabulary should be made an integral part of the instructional programs in mathematics.

2. The study of quantitative vocabulary should begin in the primary grades.

3. Pupils should be provided with opportunities to use quantitative vocabulary in both written and oral communication.

4. Pupils should be provided with rich and varied experiences that will furnish a background for the new terms to be encountered.

5. Classrooms in elementary schools should be equipped with a variety of arithmetic aids to help clarify the meanings of mathematical terms.

6. Direct-study techniques should be used to teach the technical and semi-technical vocabulary in each of the content areas. Pupils who do not understand the technical vocabulary in each

of the content subjects will not comprehend many of the important concepts to be learned. The study of the technical vocabulary in mathematics cannot be left to chance but must be an integral part of the mathematics program.

Summary

There seems to be general agreement among researchers that certain reading skills are necessary for success in mathematics. In addition to intellectual factors, the following four areas were found to be of significance:

1. General reading skills, including vocabulary, word recognition, and comprehension.

2. Problem solving reading skills, including comprehension of the problem statement, selection of relevant details, and selection of the proper solution procedure.

3. Mechanical computation and a mathematical understanding of the concept of quantity, the number system, and important relationships.

4. A spatial factor, involving the ability to visualize objects and symbols in more than one dimension and to use mental imagery to clarify word meanings.

Obviously, reading is not the only factor in a student's success with mathematics. Certain intellectual capacities are also essential for mathematics achievement.

CHAPTER III

EXPERIMENTAL DESIGN, METHODS, AND PROCEDURE

The purpose of this chapter is to describe the methods used in conducting the investigation. Included are descriptions of subjects, materials, and statistical design employed.

Description of Subjects

Participants in this study were all the third- and fourth-graders at Lucy D. Anthony School in Madison, New Jersey. A total of 66 students, 32 third-graders and 34 fourth-graders were the subjects of this investigation. The participating students were heterogeneously divided into two third grade and into two fourth grade self-contained classes. A wide range of abilities existed in all four groups. (see Table 1 on page 34). Students came from a variety of socio-economic and educational backgrounds.

For purposes of this experiment, one of the third grade and one of the fourth grade classes were assigned to the experimental group, and the other third and fourth grade classes comprised the control group. Thirty-three students were assigned to the experimental condition and thirty-three to the control condition.

Description of Materials

Materials developed for this study incorporated mathematical vocabulary which appears in the Addison-Wesley third and fourth grade texts, Investigating School Mathematics (Eicholz, O'Daffer, and Fleenor, 1973). This is the mathematics text used by all the students in the school. Additionally, the I.R.A. (International Reading Association) list of the most frequently used mathematics vocabulary compiled by Earle (1976) served as another resource in choosing the list of mathematical words presented to the experimental group. A list of the words which were taught to the experimental group appears in Appendix A.

Four types of instructional materials were used with the experimental group. Filmstrips and motion pictures introduced and developed the word and symbol meanings. Concrete models and pictures were used to develop additional understandings. Experimenter-constructed table games provided drill and reinforcement of the vocabulary. A list of the audio-visual materials is in Appendix B. For illustrations of the table games, refer to Appendix C.

Vocabulary was selected from the following mathematical topics:

1. Set theory.
2. Addition, subtraction, multiplication, and division of whole numbers.

3. Word problems incorporating the four basic operations.
4. Geometry and measurement.
5. Number theory.
6. Fractions.

All of the above topics are taught at the third and fourth grade levels. They appear in the Addison-Wesley mathematics texts and in supplementary materials such as the SRA kits, Addison-Wesley activity cards, and others.

Experimental Procedure

The experimenter taught the same mathematical vocabulary to the third and fourth grade groups separately. Identical procedures and materials were used with both groups. The experimental third and fourth grade were taught separately because smaller instructional groups are easier to manage. Contact time was 45 minutes a day for each group.

Two days each week, vocabulary was introduced through filmstrips, motion pictures, and models, followed by discussion. Each student kept a notebook with definitions of the words introduced. On subsequent days, each student spent equal periods of time using games to reinforce the same vocabulary.

The experimental treatment restricted itself to instruction in mathematical vocabulary. Care was taken not to give the subjects any additional practice in computational skills. All regular mathematics instruction was provided by each of the four homeroom teachers.

In order to work with the fourth grade experimental group separately, the experimenter had a team-teaching arrangement with that fourth grade teacher. While the experimenter taught mathematical vocabulary to the fourth grade group, the fourth grade teacher taught social studies to the experimental third grade class.

While each experimental group was receiving mathematical vocabulary training, the control groups were taught social studies by their classroom teachers. Although the control groups were introduced to new mathematical vocabulary as it was encountered in the mathematics text, the students in these groups were not exposed to the films or to any of the supplementary drills.

The experimenter did not examine any of the pre-test results until after the conclusion of the experiment. This procedure was followed, in order to achieve the "double-blind condition." (Stanley and Campbell, 1963).

Tests

The Stanford Diagnostic Mathematics Test, Green Level, Forms A and B was used to evaluate initial problem solving ability and to determine group gains at the end of the study. Alternate form reliability of this test ranges from .82 to .89.

In order to control for possible uneven difficulty, the tests were administered in an ABBA paradigm. Half of the experimental and half of the control group received the A Form of the pretest. At the end of the investigation, subjects who had been administered Form A were presented with Form B. Those who had previously been given Form B received Form A.

A Mathematical Vocabulary Test constructed by the experimenter was given to evaluate initial familiarity and to determine group gains at the end of the study. This test consisted of 50 multiple choice items. The sources of vocabulary used in this test were the Addison-Wesley text Investigating School Mathematics, Levels 3 and 4 (Eicholz, O'Daffer, and Fleenor, 1973) and the I.R.A. (International Reading Association) list of the most frequently appearing words in mathematics texts. (Earle, 1976) Two forms of the vocabulary test were constructed. They were labeled Form A and Form B. The Mathematical Vocabulary Test appears in Appendix D.

The Mathematical Vocabulary Test was also administered in an ABBA paradigm. The same alternating procedure was used as in the administration of the Stanford Diagnostic Mathematics Test.

The Cognitive Abilities Test (Thorndike and Hagen, 1971) was administered by the school system six months prior to the study. The results of this test were used in the final analysis of the experimental data, in order to achieve control for variables of intelligence. The final statistical analysis took into account the relationship between the two groups.

Pilot Study

To establish the reliability of the Mathematical Vocabulary Test, the test was administered to a group of third graders in another school of the Madison School System. A total of 40 students participated in the pilot study. The "Rational Equivalence" Method (Garrett, 1958) was used to check the reliability of the Mathematical Vocabulary Test. The formula used was as follows:

$$r_{11} = \frac{n\sigma^2 - M(n-M)}{\sigma^2_t (n-1)}$$

Practice has shown that the above formula provides a good index of the test's reliability, even when the assumption of equal item difficulty is not satisfied. In providing minimum reliability the "Rational Equivalence" Method is at least as reliable as other methods. (Garrett, 1958) The reliability yielded was an acceptable .83.

All the questions on the Mathematical Vocabulary Test could be scored in an objective manner. Therefore, the subjectivity of the experimenter was not a factor in the results obtained.

Statistical Design and Treatment of Data

The experimental design was a pre-test/post-test design in which means of each group were computed and compared on all of the tests. Schematically the study can be represented as follows:

$$R \quad O_1 \quad X_1 \quad O_2$$

$$R \quad O_3 \quad X_2 \quad O_4$$

R = Random assignment of pupils (in class groups) to separate treatments.

X = Symbol for the independent variables.

O = Measuring or testing procedure.

Raw scores from the Mathematical Vocabulary Test were used to determine mathematical reading ability. All of the scores of the experimental and control groups were averaged. A "t" test for significant differences between means was applied to the above test results. Differences at the .05 level were considered to be significant.

The Stanford Diagnostic Mathematics Test was used to determine problem solving ability. A "t" test was applied to the test results to determine the effects of vocabulary training on problem solving ability. Differences at the .05 level were considered to be significant.

CHAPTER IV

RESULTS AND DISCUSSION

Comparisons between the experimental and control groups were made by analyzing the mean scores of each group on the following tests:

1. The Houghton-Mifflin Congnitive Abililities Test.
2. The experimenter-constructed Mathematical Vocabulary Test, Forms A and B.
3. The Stanford Diagnostic Mathematics Test, Green Level, Forms A and B.

The data collected were analyzed to determine the effects of mathematical vocabulary training on problem solving ability.

The hypotheses were as follows:

1. There would be no significant differences between the experimental group and the control group in mathematical reading ability, as measured by the experimenter-constructed vocabulary test.

2. There would be no significant differences between the experimental group and the control group in problem solving ability, as measured by the Stanford Diagnostic Mathematics Test.

Results

Comparison of Experimental and Control Groups on the Houghton-Mifflin Cognitive Abilities Test

The mean IQ of the experimental group was 109, and the mean IQ of the control group was 108. A "t" test was done to determine whether the slight difference between the mean scores of the two groups was of statistical significance. A "t" of .38 was obtained. This figure is not significant enough to affect the final interpretation of the experimental results. Therefore, any differences between the groups would not be attributable to differences in intelligence. (Refer to Table 1).

Mean Differences Between Experimental and Control Groups on Mathematical Vocabulary Tests

The first hypothesis raised the question whether mathematical vocabulary training would increase mathematical reading ability of the experimental group as compared to the control group.

TABLE 1

DISTRIBUTION OF IQ SCORES ON COGNITIVE ABILITIES TEST FOR EXPERIMENTAL AND CONTROL GROUPS

Experimental Group		Control Group	
Subject	Score	Subject	Score
1	76	1	92
2	119	2	90
3	92	3	113
4	108	4	105
5	127	5	125
6	111	6	120
7	127	7	122
8	107	8	79
9	92	9	125
10	127	10	94
11	114	11	112
12	121	12	102
13	131	13	107
14	106	14	109
15	122	15	121
16	119	16	108
17	101	17	70
18	132	18	88
19	59	19	123
20	119	20	108
21	110	21	119
22	115	22	138
23	94	23	121
24	113	24	91
25	106	25	108
26	134	26	114
27	101	27	127
28	99	28	105
29	109	29	105
30	95	30	107
31	111	31	106
32	111	32	105
33	118	33	113
Experimental Group Mean - 109		Control Group Mean - 108	

On the Mathematical Vocabulary Test, the experimental group achieved a pre-test mean raw score of 30.90 and a post-test mean of 38.81. The control group had a raw score mean of 33.33 on the pre-test and a raw score mean of 36 on the post-test. The experimental group showed a mean raw score gain of 7.91, and the control group had a mean raw score gain of 2.67.

The difference between the experimental group and the control group mean scores on the pre-test was in favor of the control group. However, the difference was slight. There is no question that the two groups differ greatly with respect to average performance on the post-test. A statistical test which takes the initial difference into account is based on gain scores. (Guilford, 1956) It is for this reason that "t" tests of significance were applied to gain scores of the subjects' performance on the Mathematical Vocabulary Test as well as on the Stanford Diagnostic Mathematics Test.

On the Mathematical Vocabulary Test gain scores a "t" of 3.77 was obtained. This indicates that there was a statistically significant difference between the two groups at the .001 level. (See Table 2).

In view of these findings, the first hypothesis may safely be rejected. Significant gains were achieved by the experimental group, as a result of mathematical vocabulary training.

TABLE 2

COMPARISON OF GAIN SCORES BETWEEN THE EXPERIMENTAL AND CONTROL GROUPS ON MATHEMATICAL VOCABULARY TEST

Group	N	Pre-Test Mean	Post-Test Mean	Gain	"t"
Experimental	33	30.90	38.81	7.91	
Control	33	33.33	36.00	2.67	
					3.77*

t (df = 64) $p < .05$ ("t" test computed on gain scores)

* Significant at $p < .05$

Comparison of the Experimental and Control Groups on the Stanford Diagnostic Mathematics Test

The second hypothesis raised the question whether there would be gains in problem solving ability of the experimental group, as measured by the Stanford Diagnostic Mathematics Test, Green Level, Forms A and B. This hypothesis was tested by two of the sub-tests: Test I - Number System and Numeration and Test III - Applications. Test II - Computation was not used in the evaluation of this experiment, since it concerns itself entirely with straight computation skills, without incorporating any reading skills.

On Test I: Number System and Numeration, the experimental group achieved a pre-test raw score mean of 19.67 and a post-test raw score mean of 29.1. The control group attained a pre-test raw score mean of 21.75 and a post-test raw score mean of 28. The experimental group showed a mean raw score gain of 6.25. A "t" of 2.63 was obtained on the comparison of gain scores between the experimental and the control groups. Fisher's Table indicates that this figure is significant at the .02 level. (See Table 3.)

On Test III: Applications, the experimental group showed a pre-test raw score mean of 14.12 and a post-test raw score mean of 22.79. This represented a mean gain of 8.67. The control group had a pre-test raw score mean of 17.75 and a post-test raw score

TABLE 3

COMPARISON OF GAIN SCORES BETWEEN THE EXPERIMENTAL AND CONTROL GROUPS ON THE STANFORD DIAGNOSTIC MATHEMATICS TEST - TEST 1: NUMBER SYSTEM AND NUMERATION

Group	N	Pre-Test Mean	Post-Test Mean	Gain	"t"
Experimental	33	19.67	29.1	9.43	
Control	33	21.75	28.00	6.25	
					2.63*

t (df = 64) $p < .05$ ("t" test computed on gain scores)

* Significant at $p < .05$

mean of 21.59. The control group showed a mean gain of 3.84, considerably less than that of the experimental group. A "t" of 4.24 indicated a significance level greater than .001. (See Table 4.)

The second hypothesis can also be rejected, on the basis that the experimental group achieved significantly higher gain scores than the control group on Tests I and III of the Stanford Diagnostic Mathematics Test. Both of these tests, but especially the test dealing with Applications, incorporate a reading component which was dealt with in the mathematical vocabulary training.

Discussion

The results of this study appear to be in agreement with previous studies discussed in Chapter II. Balow (1964), Johnson (1949), and Vanderlinde (1964) reported that students who had participated in quantitative vocabulary training programs achieved significantly higher scores on tests of mathematical problem solving than students who had not received any special training in mathematical vocabulary. These investigators had worked with upper elementary level students.

TABLE 4

COMPARISON OF GAIN SCORES BETWEEN THE EXPERIMENTAL AND CONTROL GROUPS ON THE STANFORD DIAGNOSTIC MATHEMATICS TEST - TEST III: APPLICATIONS

Group	N	Pre-Test Mean	Post-Test Mean	Gain	"t"
Experimental	33	14.12	22.79	8.67	
Control	33	17.75	21.59	3.84	
					4.24*

t (df = 64) $p < .05$ ("t" test computed on gain scores)

* Significant at $p < .05$

On the basis of the present study, it appears that mathematical vocabulary training was also effective with third- and fourth-graders. It is interesting to note that the control group scored higher on all of the pre-tests. The question arises how this group would have performed, if it had been exposed to a program of mathematical vocabulary training. Would post-test results have increased in proportion to those of the experimental group?

It is possible that even greater effects would probably be observed if mathematical vocabulary training were extended over a longer period of time than the eight weeks devoted to this experiment. Even greater benefits may be observed if such vocabulary training were made an integral part of work in mathematics programs from the time when formal study of the subject is first begun.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

The purpose of this study was to determine whether systematic mathematical vocabulary training would have any effect on the problem solving ability of third- and fourth-graders. Another objective of the experiment was to compare the gains in mathematical reading ability of the experimental and the control groups.

The experimental group was taught 120 words which were selected from the Addison-Wesley Mathematics text Investigating School Mathematics and from the I.R.A. list of the most frequently appearing words in mathematics texts. The vocabulary was introduced through the following media:

1. Filmstrips and Motion Pictures
2. Concrete Models
3. Pictures.

Students kept notebooks of mathematical terms. Drill and reinforcement were provided through discussions and games. Mathematical vocabulary training took place four days a week, for 45 minutes each day, over a period of eight weeks.

The Stanford Diagnostic Mathematics Test and the experimenter-designed Mathematical Vocabulary Test served as measuring instruments. Because the control group had achieved higher scores on the pre-tests than the experimental group, the final evaluation of the study concerned itself with a comparison of the gain scores between the two groups. The experimental group made statistically significant gains on the Mathematical Vocabulary Test and on the Stanford Diagnostic Mathematics Test, especially on the subtest of Applications. Therefore, it can be concluded that there is a significant relationship between the knowledge of specific mathematical terms and the solution of problems involving these terms.

Conclusions

The findings of this study are similar to those of Johnson (1944) who conducted an experiment with seventh grade students. He also had found that the experimental group which had received mathematical vocabulary training exhibited significant gains in both mathematical vocabulary and in problem solving.

It is interesting to note that Johnson's group was given a retention test three months after the close of the experiment. The experimental group was still statistically significant to the control group in the knowledge of mathematical vocabulary. The

findings of Johnson's study are very encouraging from a long range point of view, and they appear to reinforce the rationale for mathematical vocabulary training.

On the basis of the present study, it may be concluded that mathematical vocabulary training is also of value at the third and fourth grade levels.

Directions for Future Research

The following questions might prove profitable as topics for future research:

1. Would similar results be obtained if mathematical vocabulary training were introduced at the first and second grade levels?

2. Would greater benefits be derived if mathematical vocabulary development were extended over a period of several grades?

An important aspect of the present study was the extensive use of audio-visual aids in the development of mathematical vocabulary. It may be interesting to conduct an investigation which would incorporate a more varied collection of audio-visual aids,

such as the language master, tape recorder, video tape, and possibly others. A comparison of the effectiveness of such aids and devices for teaching mathematical vocabulary may be of pedagogical value, especially when attempts are made to make instructional provisions for varied cognitive styles.

Research has shown that word power is basic to comprehension power, and for the study of mathematics basic to problem solving power. Therefore, it may be worthwhile to conduct a study of this type with disadvantaged students or ones with limited language background.

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APPENDIX A

MATHEMATICAL VOCABULARY AND SYMBOLS

MATHEMATICAL VOCABULARY AND SYMBOLS

Set Theory

Element
Equivalent Sets
Empty Sets
Intersection
Union
Subset

Addition and Subtraction

Add
Addend
Addition
Difference
Less
Minus
More
Ones
Place Value
Plus
Regroup
Subtract
Sum
Tens

Multiplication and Division

Divide
Dividend
Division
Factor
Multiplication
Multiply
Product
Times
Quotient

Measurement

Area
Cent-
Centi-
Centimeter
Cube
Decimeter
Estimate
Foot
Gallon
Gram
Inch
Kilogram
Kilometer
Length
Line
Liter
Meter
Metric
Mile
Millimeter
Minute
Ounce
Perimeter
Pint
Pound
Quart
Segment
Ton
Volume
Yard

Geometry and Graphing

Angle
Center
Circle
Closed
Congruent
Continuous
Coordinate
Diagonal
Diameter
Graph
Hexagon
Midpoint
Parallel
Parallelogram
Pentagon
Perpendicular
Polygon
Quadrilateral
Radius
Ray
Rectangle
Square
Symmetrical
Symmetry
Triangle
Vertex
Vertices

Fractions

Denominator
Fraction
Numerator
One-Fourth
One-Half
One-Third
One Whole

Number Theory

Associative
Cummutative
Digit
Distributive
Even
Exact
Grouping
Inequality
Inverse
Numeral
Odd
Order
Period
Rounded

Mathematical Symbols

+	Plus
-	Minus
x	Times
÷	Divided
∪	Union of Sets
∩	Intersection of Sets
⊂	Subset
{}	Empty Set
=	Equal
≠	Not Equal
>	Greater Than
>	Less Than

APPENDIX B

LIST OF AUDIOVISUAL MATERIALS

FILMSTRIPS

Coronet

1. Stories About Shapes.

Guidance Associates

1. Comparison: Putting a Symbol to Work.
2. Number Patters: Puzzles with a Purpose.
3. Measurement: How to Say How Much.
4. Making Sense of Sets.
5. More About Sets.
6. Addition.
7. Subtraction.
8. Multiplication.
9. Division.
10. Beginning Geometry.

SVE (Society for Visual Education)

1. Division.
2. Money and Time.
3. Fractions: A New Approach.

16 mm Films

BFA Educational Media

Doing and Undoing in Mathematics - Inverses.

Learning about Metric Measure.

Corf

Language of Graphs.

Disney

Donald in Math - Magicland.

Encyclopedia Britannica
Educational Corporation (EBEC)

Meaning of Plus and Minus.

Time for Clocks.

Weights and Measures.

Journal

Multiplication.

McGraw-Hill

Associativity.

Commutativity.

Inequalities.

Inverse Operations.

Parts of Things.

Sets and Numbers.

Teen Numbers.

Modern Learning Aids (MLA)

Introduction to Fractions.

Silbur

Between the Whole Numbers.

Remainder in Division.

APPENDIX C

SAMPLE GAME ILLUSTRATIONS

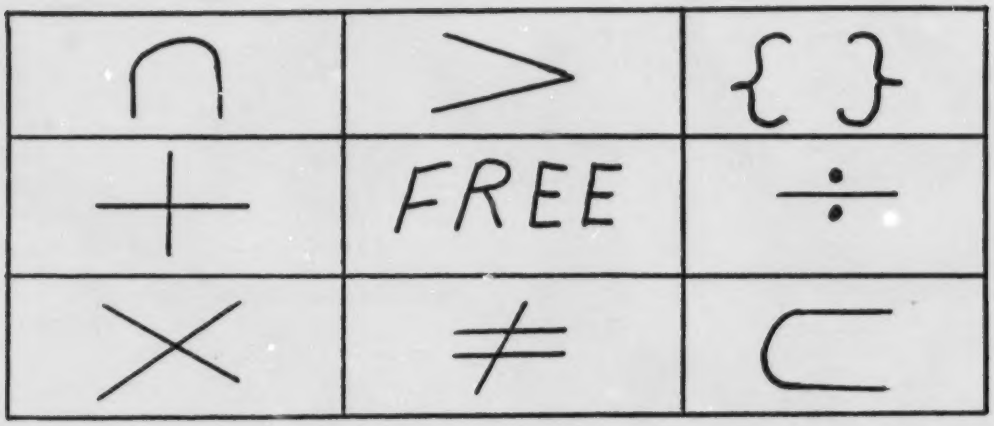
BEAN BAG

SUBSET	$<$	ODD NUMBER	$>$	FACTOR	$+$
UNION	$-$	SUM	$\times$	EVEN NUMBER	$\div$
SET	ADD	EQUIVALENT	DIFFERENCE	QUOTIENT	INTER-SECTION
PRODUCT	$=$	EMPTY SET	SUBTRACT	$\cup$	$\neq$

Directions:

1. Divide into two teams.
2. First person tosses the bean bag on the board and tells about the term or symbol on which the bean bag lands.
3. If he is right, his team gets a point.
4. Person from other team does the same.
5. The team with the most points wins.

MATH SYMBOL BINGO



Directions:

1. Each player takes a bingo card.
2. Each player takes turns being the caller.
3. Player number 1 draws a card from a pile placed in the center of the table. He says, "Cover the symbol for division," or whatever word is drawn. The other players repeat above procedure.
4. Those who have a word or symbol on their bingo card, cover it with a marker.
5. The first player to get Bingo wins.

MATH BINGO

DIGIT	TRIANGLE	SUBSET	FRACTION	QUOTIENT
FACTOR	PENTAGON	DIAMETER	ONE-HALF	PLUS
TIMES	SUM	FREE	EVEN	GREATER THAN
SEGMENT	NOT EQUAL	NUMERATOR	ASSOCIATIVE	SQUARE
CUBE	INVERSE	COMMUTATIVE	DENOMINATOR	POLYGON

Directions:

1. Each player takes a bingo card.
2. Each player takes turns being the caller.
3. Player number one draws a card and says, "Cover the word DIAMETER." The other players repeat above procedure.
4. Those who have the word called on their bingo board, cover it with a marker.
5. The first player to get Bingo wins.

APPENDIX D

MATHEMATICAL VOCABULARY

TEST: FORMS A AND B

MATHEMATICS VOCABULARY TEST

FORM A

Directions: Underline the best answer.

1. The answer to an addition problem is called

   a. sum

   b. difference

   c. product

2. To find the difference between two numbers, you

   a. add

   b. divide

   c. subtract

3. A square has

   a. two equal sides

   b. four equal sides

   c. six equal sides

4. A number to be added to another number is called

   a. a factor

   b. an addend

   c. a sum

5. The answer to a multiplication problem is called a

   a. product

   b. quotient

   c. difference

6. In the problem $12 \div 3$, 3 is the

   a. dividend

   b. divisor

   c. quotient

7. The minus sign is used in

   a. addition

   b. subtraction

   c. division

8. Subtraction is the inverse of

   a. division

   b. multiplication

   c. addition

9. In the equation $7 < 9$, 7 is

   a. greater than 9

   b. equal to 9

   c. less than 9

10. The symbol ≠ means

    a. not equal to

    b. equal to

    c. less than

11. A set with no objects in it is called

    a. an empty set

    b. a full set

    c. an equivalent set

12. Two sets which do not contain the same number of objects, are

    a. equivalent

    b. empty

    c. not equivalent

13. A geometric figure with <u>four equal</u> sides is called

    a. a triangle

    b. a circle

    c. a square

14. The <u>order principle</u> is also called

    a. the commutative principle

    b. the grouping principle

    c. none of the above

15. The associative principle is also called

    a. the grouping principle

    b. the order principle

    c. both of the above

16. The number 7 is

    a. an even number

    b. an odd number

    c. a composite number

17. In subtraction, regrouping means

    a. to borrow

    b. to carry

    c. to take away

18. A three-sided figure is called a

    a. square

    b. triangle

    c. rectangle

19. An angle is

    a. two rays with the same endpoint

    b. a triangle

    c. a five-sided polygon

20. A <u>triangle</u> has

    a. three line segments

    b. three rays

    c. five points

21. A closed geometric figure with three or more sides, is called

    a. polygon

    b. line

    c. angle

22. The point that two rays of an angle have in common is called

    a. vertex

    b. segment

    c. ray

23. The distance from the center of the circle to the outside of the circle is called

    a. diameter

    b. radius

    c. angle

24. Two lines that are the same distance apart are

    a. parallel

    b. continuous

    c. perpendicular

25. A centimeter is a unit of

    a. length

    b. weight

    c. volume

26. A kilometer is used to measure

    a. weight

    b. distance

    c. volume

27. A kilogram is a unit of

    a. length

    b. volume

    c. weight

28. A millimeter is used to measure

    a. volume

    b. weight

    c. length

29. A meter is a unit of

    a. weight

    b. length

    c. volume

30. To find out how may pieces of candy were sold altogether, you would

    a. add
    b. subtract
    c. divide

31. John has 40 cents. How much more money does he need to buy a 60 cent toy? To find the answer you would

    a. add
    b. multiply
    c. subtract

32. Cent means

    a. the 100th part of a dollar
    b. half a dollar
    c. none of the above

33. To check your answer in an addition problem, you would

    a. add
    b. subtract
    c. multiply

34. The inch is a unit of

    a. weight

    b. length

    c. volume

35. The pound is used to measure

    a. length

    b. weight

    c. volume

36. Geometric figures with the same shape and size are called

    a. congruent

    b. parallel

    c. polygons

37. The quart is a unit of

    a. length

    b. weight

    c. volume

38. The pint is used to measure

    a. volume

    b. length

    c. height

39. In the numeral 264, the 2, 6, and 4 are called

    a. tens

    b. hundreds

    c. digits

40. The name for the fraction 1/2 is

    a. one whole

    b. one-half

    c. one-fourth

41. The equation 3 + 2 = 2 + 3 is an example of the

    a. distributive property

    b. commutative property

    c. associative property

42. In the problem, 5 x 9, 9 is a

    a. digit

    b. quotient

    c. factor

43. The sum of the lengths of the sides of a triangle is called

    a. angle

    b. perimeter

    c. area

44. The estimate means to

    a. tell exactly

    b. approximate

    c. give the opposite

45. A coordinate is a

    a. polygon

    b. number pair used in graphing

    c. graph

46. A five-sided figure is called a

    a. circle

    b. pentagon

    c. square

47. The symbol $\cup$ means

    a. intersection of sets

    b. union of sets

    c. less than

48. The symbol for empty set is

    a. {}

    b. $\cup$

    c. $\cap$

49. A <u>rounded</u> number is

    a. exact

    b. approximate

    c. equal

50. The symbol ⌐ means

    a. divide

    b. multiply

    c. subset

MATHEMATICS VOCABULARY TEST

Form B

Directions: Underline the best answer.

1. The answer to a subtraction problem is called the

   a. difference

   b. sum

   c. quotient

2. To get a total of two numbers you

   a. subtract

   b. multipy

   c. add

3. A square is a

   a. rectangle

   b. four-sided figure

   c. both of the above.

4. To get a product of two numbers you

   a. multiply

   b. add

   c. divide

5. The answer to a division problem is called a

   a. product

   b. quotient

   c. difference

6. In the problem, 4 x 5, 5 is

   a. an addend

   b. a factor

   c. a product

7. The plus sign is used in

   a. subtraction

   b. addition

   c. multiplication

8. Division is the inverse of

   a. multiplication

   b. subtraction

   c. division

9. In the equation 8 > 7, 8 is

   a. less than 7

   b. greater than 7

   c. equal to 7

10. The symbol $\neq$ means

    a. less than

    b. equal to

    c. not equal to

11. An <u>empty set</u> has

    a. no objects in it

    b. two objects in it

    c. ten objects in it

12. Two <u>equivalent sets</u> have

    a. different values

    b. the same number of objects

    c. nothing in common

13. A <u>rectangle</u> has

    a. four equal sides

    b. four right angles

    c. none of the above

14. The <u>commutative principle</u> is also called

    a. the grouping principle

    b. the order principle

    c. none of the above

15. The grouping principle is also called

    a. the order principle

    b. the associative principle

    c. both of the above

16. The numeral 8 is

    a. an odd number

    b. an even number

    c. a prime number

17. In addition, regrouping means to

    a. carry

    b. borrow

    c. add

18. A triangle

    a. is a three-sided figure

    b. always has three equal sides

    c. is a four-sided figure

19. Two rays with the same endpoint make up

    a. an angle

    b. a triangle

    c. a five-sided figure

20. A closed figure made up of 3 line segments is called

    a. a square

    b. a triangle

    c. a circle

21. A triangle is a

    a. polygon

    b. rectangle

    c. circle

22. A vertex is found in

    a. an angle

    b. a circle

    c. a line

23. The distance across the center of a circle is called

    a. diameter

    b. radius

    c. angle

24. A polygon with four sides is

    a. quadrilateral

    b. parallel

    c. an angle

25. A polygon is

    a. a closed geometric figure with three or more sides

    b. a line segment

    c. an angle

26. A meter is a unit of

    a. weight

    b. length

    c. volume

27. A liter is used to measure

    a. weight

    b. length

    c. volume

28. A gram is a unit of

    a. length

    b. weight

    c. volume

29. A kilogram is used to measure

    a. weight

    b. volume

    c. distance

30. A kilometer is a unit of

    a. length

    b. weight

    c. volume

31. Andy has 30 cents. How much more money does he need to buy a 50 cent puzzle? To get the answer, you would

    a. subtract

    b. add

    c. divide

32. Jane has 50 cents. Mary has 45 cents. To find out how much money they have altogether, you would

    a. subtract

    b. multiply

    c. add

33. The prefix centi means

    a. 1000

    b. 100

    c. 10

34. To check your answer in a subtraction problem, you would

    a. divide

    b. multiply

    c. add

35. The yard is used to measure

    a. weight

    b. length

    c. volume

36. The ounce is a unit of

    a. length

    b. volume

    c. weight

37. The quart is used to measure

    a. length

    b. weight

    c. volume

38. Congruent figures have

    a. same size and shape

    b. unequal angles

    c. vertices

39. In the numeral 186, the 1, 8 and 6 are called

    a. digits

    b. periods

    c. hundreds

40. The name for the fraction 1/4 is

    a. one-third

    b. one-fourth

    c. one-half

41. The equation 5 + 7 = 7 + 5, illustrates the

    a. commutative property

    b. distributive property

    c. associative property

42. In the problem 12 ÷ 6, 12 is a

    a. product

    b. dividend

    c. quotient

43. The sum of the lengths of the sides of a square is called

    a. perimeter

    b. area

    c. angle

44. The estimate means to

a. find out exactly

b. approximate

c. take a wild guess

45. A pentagon is a

a. four-sided figure

b. circle

c. five-sided figure

46. The number sentence $3 < 9$ is called

a. an inequality

b. equivalent set

c. division

47. The symbol $\cap$ means

a. union of sets

b. less than

c. intersection of sets

48. The symbol {} means

a. greater than

b. empty set

c. union of sets

49. The symbol for <u>divide</u> is

    a. {}

    b. ÷

    c. ⟌

50. A <u>rounded</u> number is

    a. equal

    b. approximate

    c. exact